K4.24 FISH VALUES

The following discussion provides an analysis of potential impacts on fish and wildlife from the discharge of treated mine effluent to the environment that may result from project operations. The analysis is based on predicted concentrations as described in Section 4.18 and Appendix K4.18, Water and Sediment Quality; and Section 4.20 and Appendix K4.20, Air Quality. For a detailed description of study methods and results of the project trace elements study, please refer to Chapters 10 and 35 of the Environmental Baseline Data (EBD) reports. All EBD tables referenced herein are available in Chapter 10.

A discussion of instream flow modeling is also included below.

K4.24.1 Selenium

Selenium has a narrow range between essentiality and toxicity. As an essential nutrient, selenium is incorporated into functional and structural proteins; aquatic and terrestrial organisms require low levels of dietary selenium to sustain metabolic processes (Palace et al. 2004). Dietary requirements for fish ranges from 0.05 to 1.0 milligram of selenium per kilogram (mg/kg) on dry weight basis (Watanabe et al. 1997). Selenium deficiency may affect humans, sheep and cattle, deer, fish, aquatic invertebrates, and algae (EPA 2016). Toxicity occurs in fish at an order of magnitude greater level than required to avoid deficiency (Palace et al. 2004).

Selenium is considered to be one of the most toxic but essential elements (Chapman et al. 2010). Chronic exposure to selenium can cause reproductive impairments (e.g., larval deformity or mortality) and also adversely affect growth and mortality in fish and aquatic invertebrates (e.g., larval deformity or mortality). The most well-documented toxic symptoms in fish are reproductive teratogenesis (formation of defects in developing embryos) and larval mortality. Egg-laying vertebrates appear to be the most sensitive taxa, with toxicity resulting from maternal transfer of selenium to eggs. Lethal and sublethal deformities can occur in developing fish exposed to selenium, affecting both hard and soft tissues (Lemly 1993b). Deformities in fish that affect feeding or respiration can be lethal shortly after hatching. Non-lethal deformities, such as distortions in the spine and fins, can reduce swimming ability and overall fitness. The US Environmental Protection Agency's (EPA) updated 2016 recommended water quality criteria represent the level below which aquatic impacts do not occur; these levels are 15.1, 8.1, and 11.3 mg/kg on dry weight in egg or ovary, whole body, and muscle, respectively.

The initial bioconcentration of selenium into primary producers from the dissolved phase is also the largest and potentially the most variable step in the trophic transfer of selenium (approximately 100 to 1,000,000-fold bioconcentration). At higher trophic levels, bioaccumulation occurs primarily through the dietary pathway (Presser and Ohlendorf 1987; Saiki and Lowe 1987; Luoma et al. 1992; Maher et al. 2010). Dissolved selenium does not contribute substantially to selenium bioaccumulation in higher trophic animals under environmentally relevant conditions (Lemly 1985; Ogle and Knight 1996).

Primary producers (trophic level 1 organisms such as periphyton, phytoplankton, and vascular macrophytes) assimilate dissolved selenium in their tissues. Next, aquatic primary consumers (trophic level 2 organisms such as zooplankton, insect larvae, larval fish, and bivalves) take up selenium from these primary producers and other particles. Predators (trophic level 3 and above such as fish and birds) then accumulate selenium progressively via the food web.

The type of waterbody (e.g., lentic [still] versus lotic [flowing]), and the type of food web influences selenium bioaccumulation in higher trophic organisms. Organisms in lakes, ponds, reservoirs, wetlands, or estuaries would tend to bioaccumulate more selenium than those living in waters with shorter residence times such as rivers and streams (Luoma and Rainbow 2005; Simmons and Wallschlägel 2005). In aquatic systems with similar dissolved selenium concentrations, fish that consume primarily freshwater mollusks would exhibit greater selenium bioaccumulation than fish that consume primarily insects or crustaceans because mollusks tend to bioaccumulate more selenium than other trophic level 2 organisms (Luoma and Presser 2009; Stewart et al. 2004).

For birds, dietary selenium requirements appear to be between 0.05 and 0.5 mg/kg. Elevated dietary selenium in birds just before egg-laying can result in reproductive, teratogenic, and other toxic effects due to maternal transfer of selenium to eggs (Ohlendorf and Heinz 2011). However, selenium sensitivity among different bird species varies. Interpretive guidelines based on available data on selenium toxicity to birds indicate that selenium deficiency occurs generally below dietary concentrations of 0.30 mg/kg dry weight and toxicity occurs generally above 5.0 mg/kg dry weight (Ohlendorf and Heinz 2011).

K4.24.1.1 Selenium Impacts to Aquatic Species and Wildlife

As summarized above, fish and bird species are the species groups most sensitive to selenium toxicity due to maternal transfer in eggs. The primary exposure pathway of concern is aquatic bioaccumulation and subsequent food chain biomagnification. Predicted project-related changes in selenium concentrations in various waterbodies, during operations and post-closure activities, are not sufficiently large to adversely impact sensitive fish and bird populations via aquatic or bioaccumulation pathways.

Predicted selenium concentrations in treated effluent discharges from water treatment plants (WTPs) range from 0.537 to 2.9 micrograms per liter (µg/L) during mine operations and various closures stages (see Table K4.18-13 through Table K4.18-16). Treatment prior to discharge would achieve the selenium discharge limit based on the Alaska Department of Environment Conservation (ADEC) aquatic life criteria of 5.0 µg/L. Downstream of the discharge point, concentrations of the selenium would be expected to rapidly decline due to dilution.

Changes in metals concentrations downstream of North Fork Koktuli (NFK), South Fork Koktuli (SFK), Upper Talarik Creek (UTC), and Frying Pan Lake were predicted based on a model that accounts for the effluent discharge from the WTPs, project-related dust deposition on the lake, and runoffs from surrounding terrestrial areas receiving project-related dust deposition (see Appendix K4.18). To be conservative, various assumptions are made in the model that bias the predicted concentrations to be higher than would be expected under realistic conditions. The conservative, high-end, long-term selenium concentrations in the rivers and lake are estimated to range from 0.32 to 1.4 µg/L. These predicted selenium concentrations are below ADEC's aquatic life criterion of 5.0 µg/L and the EPA's aquatic life criteria of 1.5 µg/L and 3.5 µg/L for lentic and lotic waters.

Evaluation of predicted change in surface water quality from project-related dust deposition is presented in Table K4.18-18 and Table K4.18-19. Predicted selenium concentrations in various waterbodies range from 0.27 to 0.30 µg/L (see Table K4.18-18 and Table K4.18-19), which is the same as the baseline range (i.e., dust deposition would not result in appreciable change in the surface water selenium concentrations).

The EPA's aquatic life criteria of 1.5 µg/L and 3.5 µg/L for lentic and lotic waters are derived based on bioaccumulation modeling and are protective of adverse effects on sensitive aquatic species through bioaccumulation of selenium, particularly fish species, which are the most sensitive aquatic species. Therefore, aquatic impacts to invertebrates and fish species would not be expected to occur due to project-related changes in surface water selenium concentrations.

Similarly, at the high-end prediction of 0.32 to 1.4 µg/L in surface water (see Table K4.18-18 and Table K4.18-19), aquatic organisms and fish would not be likely to accumulate selenium above 5.0 mg/kg dry weight in their tissues, which is the general, literature-based toxicity threshold of dietary selenium for birds. Therefore, at the predicted surface water selenium concentrations, impacts on bird populations through the dietary exposure pathway would also not be expected.

K4.24.2 Copper

Copper is considered one of the most toxic elements for aquatic species. However, its toxicity varies based on environmental conditions and on species sensitivity.

Due to diverse influences of physicochemical factors on copper toxicity, the specific chemistry of the exposure water determines whether appreciable adverse effects occur. Other than copper concentration, factors that influence copper toxicity include pH, hardness, alkalinity, and organic carbon. ADEC's hardness-based aquatic life criteria for copper includes hardness-based adjustments using empirical regressions of toxic concentrations versus hardness. Because of general correlation between hardness and other factors (such as pH and alkalinity), the hardness adjustments address more bioavailability factors than hardness alone. However, these factors are not addressed separately for exposure conditions in which correlations between hardness and other factors may be different. Additionally, other physicochemical factors affecting metal toxicity, such as organic carbon, are not addressed by the hardness adjustment.

In 2007, the EPA updated the aquatic life criteria for copper based on the Biotic Ligand Model (BLM), which specifically accounts for the diverse interactions of various factors that influence copper bioavailability and toxicity. The BLM approach is considered a better representation of the geochemical and biological interactions of copper than the hardness-based approach. However, in developing the BLM-based aquatic life criteria, the EPA considered only the conventional toxicity related to survival, growth, and reproduction of aquatic species, and did not include other sublethal effects that may adversely impact their populations.

Copper has been known to impair olfaction, behavior, and other chemo/mechanosensory responses in aquatic organisms, including effects to the lateral line of fish (Hara et al. 1976; Linbo et al. 2006, 2009; Hansen et al. 1999a). The lateral line of fish is composed of neurons (hair cells) that enable schooling, predator avoidance, feeding, reproduction, and returning to natal streams (Hansen et al. 1999a; Hansen et al. 1999b; McIntyre et al. 2012). Copper avoidance behavior by rainbow trout and chinook salmon has been reported at concentrations ranging from 0.7 to 9.2 µg/L (Morris et al. 2019a). Neurophysiological studies on juvenile salmonids have reported inhibitory effects on sensory epithelium or olfactory bulb at 1.9 to 8 µg/L, ranging over 0.5- to 4-hour exposures (Morris et al. 2019a). Potential importance of such sublethal effects has led to concerns that both hardness-based and BLM-based aquatic life criteria might not adequately protect fish and other aquatic organisms.

Meyer and Adams (2010), with a recent update (Meyer and DeForest 2018), evaluated the protectiveness of the hardness-based and BLM-based aquatic life criteria for copper against impairment of behavior (e.g., ability to respond to olfactory alarm cues, predatory avoidance ability, and swimming performance) and chemo/mechanosensory responses (e.g., changes in electro-olfactogram, electroencephalogram, and histopathology of olfactory or lateral-line tissue). The updated meta-analysis of relevant studies indicated that the hardness-based chronic copper criteria were less protective than BLM-based chronic copper criteria against impairment of behavior and chemo/mechanosensory responses. However, both hardness-based and BLM-based chronic criteria were protective for the majority of the cases: 73.8 percent and 95.3 percent of the cases, respectively. Additionally, the ranges of water chemistry generally overlapped considerably for protective versus under-protective cases, and were not indicative of any systematic bias based on type of water chemistry.

Recent studies have investigated whether hardness-based and BLM-based criteria are systematically less protective in low-hardness water of Bristol Bay headwaters (Morris et al. 2019a, b). Morris et al. (2019a) tested copper toxicity in low-hardness laboratory water (approximately 30 milligrams per liter [mg/L] as calcium carbonate [$CaCO_3$]), and reported that acute toxicity (median lethal toxicity or LC50) to rainbow trout occurred at 16 µg/L. In the same study, fathead minnows were exposed to laboratory and samples collected from NFK, SFK, and UTC; resulting LC50s were 29 and 79 µg/L, respectively. In the Morris et al. (2019b) study of copper toxicity toward olfactory impairment, rainbow trout was exposed to copper in a low hardness water (27 mg/L as $CaCO_3$); olfactory impairment inhibitory concentrations were reported to be 2.7 and 2.4 µg/L after 24- or 96-hour exposures, respectively. In 65 surface water samples collected from these rivers, reported copper concentrations ranged 0.18 to 2.92 (Morris et al. 2019a), which are lower than the acute toxicity values of 29 to 79 µg/L; however, at the higher range, are similar to inhibitory concentrations of 2.4 to 2.7 µg/L for olfactory impairment.

Compared to the inhibitory concentrations of 2.7 and 2.4 µg/L in the Morris et al. (2019b) study, the reported BLM-based chronic criteria were 0.63 and 0.39 µg/L, and hardness-based chronic criteria were 3.9 and 2.9 µg/L, indicating that the hardness-based criteria are not protective of olfactory impairment in rainbow trout due to copper.

Overall, evaluations of copper toxicity on behavior and chemo/mechanosensory responses in fish indicate inhibitory concentrations as low as 0.7 µg/L (as dissolved copper) depending on species, life stage, exposure duration, and water chemistry. Furthermore, hardness-based criteria and BLM-based criteria are generally protective against aquatic toxicity of copper, but they may not be protective for specific behavior and olfactory responses under specific conditions (such as low hardness).

K4.24.2.1 Copper Impacts to Aquatic and Wildlife Species

As summarized above, fish and other aquatic species are the most sensitive to copper toxicity on behavior and olfactory responses. The primary exposure pathway of concern is the direct contact to bioavailable fraction of aqueous copper. As described in the following paragraphs, predicted project-related changes in copper concentrations in various waterbodies, during operations and post-closure activities, would not be sufficiently large to adversely impact the sensitive fish populations via behavioral and olfactory impairments.

Predicted copper concentrations in treated effluent discharges from WTPs would range from approximately 1.17*10^-4 to 0.23 µg/L during mine operations and in various closures stages (see Table K4.18-13 through Table K4.18-16). Treatment prior to discharge would achieve the copper discharge limit based on ADEC aquatic life criterion of 2.2 µg/L. Downstream of the discharge point, concentrations of the copper would be expected to rapidly decline due to dilution.

The discharge limit of 2.2 µg/L is based on hardness adjustment using the lowest of the 15th percentile from the three wastewater discharge locations (approximately 17 mg/L as $CaCO_3$). Baseline hardness in the mine site surface water range from approximately 6 to 62 mg/L as $CaCO_3$ (see Environmental Baseline Document Chapter 35, Table 9.1-5 through Table 9.1-7, and Table 9.1-31 and Table 9.1-32). Hardness in effluent discharges would be expected to be higher at 3.7 to 179 mg/L as $CaCO_3$ (see Table K4.18-13 through Table K4.18-16).

Changes in metals concentrations downstream of NFK, SFK, UTC, and Frying Pan Lake were predicted based on a model that accounts for the effluent discharge from the WTP, project-related dust deposition on the lake, and runoffs from surrounding terrestrial areas receiving project-related dust deposition (see Appendix K4.18). To be conservative, various assumptions were made in the model that bias the predicted concentrations to be higher than would be expected under realistic conditions. The conservative, high-end, long-term copper concentrations in the rivers and the lake were estimated to range from less than 0.5 to 1.71 μg/L (see Table K.4.18-19). These concentrations are below the ADEC's aquatic life criterion of 2.2 μg/L, and the reported olfactory impairment threshold of 2.4 μg/L for fish in low hardness waters (Morris et al. 2019b).

Overall, site-related changes in copper concentrations in surface waterbodies would not be sufficient to cause adverse impacts to invertebrates and fish species, based on comparisons of predicted changes over baseline conditions and reported threshold concentrations of potential impacts.

K4.24.3 Cadmium

Cadmium can bioaccumulate in the tissues of aquatic life (EPA 2016). However, at criteria concentrations (i.e., at the ADEC water quality criterion), cadmium is unlikely to accumulate to levels that would result in adverse effects to aquatic invertebrates, fish, or wildlife from the ingestion of aquatic life that have accumulated cadmium in their tissues.

The biological integrity of aquatic systems is considered to be at greater risk than terrestrial systems from cadmium based on the greater sensitivity of aquatic organisms relative to birds and mammals. Freshwater biota is the most sensitive to cadmium; marine organisms are generally considered to be more resistant than freshwater organisms; and mammals and birds are considered to be comparatively resistant to cadmium. Based on this trend, criteria that are protective of aquatic life are also considered to be protective of mammalian and avian wildlife.

K4.24.4 Mercury

Methylmercury is the mercury species of greatest concern for wildlife health, because it biomagnifies in food webs, reaching high concentrations in larger, predatory organisms. Consequently, exposure via ingestion of food items is the primary exposure route for methylmercury.

Toxicokinetics and biotransformation of methylmercury and inorganic mercury differ. Methylmercury is slower to depurate than other mercury species (Scheuhammer et al. 2007) and forms complexes that are transported through the body and across placental and blood-brain barriers (Basu et al. 2005). In contrast, inorganic mercury partitions evenly in blood between protein and plasma; is poorly transported across the blood-brain barrier; and is stored primarily in the kidney and liver. Exposure to methylmercury has been hypothesized to adversely affect a wide range of biological functions in upper trophic level organisms, including neurotoxicity, blood and serum chemistry, histology, growth and development, metabolism, behavior, vision, hearing, motor coordination, and reproduction (Eisler 1987; Colborn et al. 1993; Wolfe et al. 1998).

ADEC's water quality criterion of 0.77 μg/L for mercury is based on the EPA's recommended water quality criterion that is considered protective of the aquatic life, including invertebrates and fish. Due to the bioaccummulative nature of methylmercury, several studies have attempted to establish critical tissue residue for the protection of fish. Current understanding supports a whole body tissue residue threshold of 0.21 mg/kg wet weight below which juvenile and adult fish are not impacted, and a threshold of 0.44 mg/kg above which adverse impacts may occur (Beckvar et al. 2005; Dillon et al. 2010). Adverse impacts may represent wide-ranging adverse effects discussed above.

For birds, reported threshold dietary doses range from 0.017 mg/kg body weight per day to 0.078 mg/kg body weight per day of methylmercury (Albers et al. 2007; 1976a; 1976b; Gerrard and St. Louis 2001; Longcore et al. 2007; Custer et al. 2008).

Human population at the highest risk due to methylmercury is the children of women who consume large amounts of fish and seafood during pregnancy due to its neurotoxicity. EPA's recommended fish tissue methylmercury criterion for the protection of human health is 0.3 mg/kg. Beyond this level, fish consumption may be restricted or limited through fish advisories.

Exposure to inorganic mercury occurs primarily via ingestion or direct contact. Inorganic mercury is primarily nephrotoxic in wildlife; but in some laboratory exposures, other effects have been observed, including enzyme inactivation and genotoxicity (Wolfe et al. 1998).

The dominant species of mercury transported by surface water are particulate associated with inorganic mercury, small complexes, or adsorbed to colloids and methylmercury (Flanders et al. 2010). Inorganic mercury can be converted to methylmercury by a diverse array of anaerobic microbial organisms through the process of methylation (Compeau and Bartha 1985; Fleming et al. 2006). Although methylmercury has been discharged directly to the environment in some cases (e.g., Minamata Bay, Japan [Ekino et al. 2007]), there are currently few direct anthropogenic sources of methylmercury to the environment (Boening 2000).

K4.24.4.1 Mercury Impacts to Aquatic Species and Wildlife

As summarized above, fish and bird species are the most sensitive to methylmercury toxicity due to its ability to transfer through the blood-brain and placental barrier in organisms. The primary exposure pathway of concern is the aquatic bioaccumulation and subsequent food chain biomagnification.

Mercury concentration in the effluent from WTPs at the discharge point would be estimated to be 1.6*10^-5 µg/L or lower (Table K.4.18-13 and K.4.18-14), which is orders of magnitude lower than the ADEC aquatic water quality criterion of 0.012 µg/L. Downstream of the discharge point, concentrations of mercury would be expected to represent baseline conditions.

Separate evaluation of predicted change in surface water quality from project-related dust deposition (see Table K4.18-18 and Table K4.18-19) was not estimated due to generally non-detect mercury concentrations in the baseline data. However, dust deposition would not result in appreciable change in the sediment (see Table K4.18-17) or soil (see Table 4.14-1) mercury concentrations; predicted incremental change was 0.32 percent over baseline, resulting in essentially unchanged baseline levels that would be below all applicable threshold limits for adverse impacts. Based on these findings, the project-related mercury releases would not be expected to cause adverse impacts on the environment.

K4.24.4.2 Sulfate Loading and Mercury Methylation

The permitted discharge of treated wastewater effluents is expected to cause an increased sulfate loading to project area surface waterbodies. Therefore, concerns have been raised with respect to the potential for sulfate-induced mercury methylation in the project area surface waterbodies and subsequent potential impact on human health and the environment. However, sulfate-induced formation of methylmercury is a complex process that depends not only on the sulfate loading, but on various site-specific geochemical conditions. A qualitative assessment of the potential environmental impacts of project-related sulfate discharge is provided based on the site-specific conditions and the specific role of sulfur biogeochemistry in the formation of methylmercury in the environment.

Mercury Methylation

Inorganic mercury may be methylated by microorganisms in the environment to form methylmercury, an organic form that bioaccumulates at the base of the food web and biomagnifies up the food web, posing potential threat to wildlife and humans (e.g., via consumption of fish). Therefore, an understanding of the environmental factors that influence the formation of methylmercury from inorganic mercury is important to assess the potential impact of mercury on human health and the environment.

Net methylmercury production in the environment depends on the rate of methylation relative to the rate of demethylation of methylmercury. Methylmercury production in many freshwater and marine environments occurs primarily via the microbial sulfate reduction (MSR) process (Gilmour et al. 1992; Hsu-Kim et al. 2013; Driscoll et al. 2013), although microbial iron reduction and methanogenic processes are also known to produce methylmercury (Kerin et al. 2006; Yu et al. 2013). In the MSR, sulfate-reducing bacteria (SRB) produces methylmercury as a co-metabolic product. Demethylation occurs primarily via the photochemical reduction, which dominates demethylation in the photic zones of surface water; aerobic and anaerobic microbes have also been found to demethylate methylmercury to a lesser extent (Ullrich et al. 2001).

Two site-specific factors that determine the net mercury methylation in the environment include mercury bioavailability and microbial activity with respects to SRBs (Hsu-Kim et al. 2013). Mercury bioavailability refers to the amount of mercury that can potentially be methylated; bioavailability depends on the geochemical speciation or the form of mercury in a particular environment. Microbial activity refers to presence and activity of these microbes, which depend on various geochemical factors, including sulfur biogeochemistry.

Influence of Sulfate on Mercury Methylation

Presence of sulfate generally increases mercury methylation because of its role as an electron acceptor for SRB in the MSR process (Kampalath et al. 2013). However, the MSR process results in the formation of sulfide, which strongly limits mercury bioavailability (Paquette and Helz 1997). These dual effects of sulfate on mercury methylation is further influenced by various site-specific conditions (such as nitrate, organic carbon, pH, and mercury). Therefore, the relationship between sulfate loading and methylmercury production is often too complex to be able to predict the production of methylmercury in a system.

At low concentrations, additional sulfate can stimulate MSR and mercury methylation in anaerobic conditions (Jeremiason et al. 2006). At higher concentrations, further addition of sulfate increases inorganic sulfide, which appears to decrease the availability of inorganic mercury for methylation (Hsu-Kim et al. 2013; Johnson et al. 2016). Therefore, a range of sulfate and sulfide concentrations are expected to be optimal for mercury methylation, above which mercury methylation is inhibited (Hsu-Kim et al. 2013).

A broad range in sulfate concentration has been reported in association with maximum methylation efficiency because of the variable chemical reduction of sulfate to sulfide due to site-specific differences in the geochemical differences (Pollman et al. 2017). Orem et al. (2014) observed peak surface water methylmercury concentrations at sulfate concentrations of 2 mg/L and 10 to 15 mg/L at two different areas in the Everglades. In the freshwater wetland mesocosms, Myrbo et al. (2017) reported peak surface water methylation at sulfate concentrations of 59 and 93 mg/L.

Several studies have reported inhibitory effects of sulfide on mercury methylation, but mostly in wetlands. In South Florida, Orem et al. (2011) found that sulfide at greater than 1.0 mg/L (as sulfur) inhibited mercury methylation, but not at 0.05 to 0.15 mg/L (as sulfur). In a sulfate-enriched sub-boreal Minnesota wetland due to mining discharge, Bailey et al. (2017) found that sulfide above approximately 0.65 mg/L (as sulfur) inhibited mercury methylation, with some inhibitory effects within a wider range of 0.3 to 3.0 mg/L (as sulfur). In a freshwater wetland mesocosm (Myrbo et al. 2017), onset of inhibitory effects on mercury methylation occurred at sulfide concentrations between 0.3 and 0.7 mg/L (as sulfur).

Overall, because lower sulfate concentrations may limit MSR rates (Holmer and Storkholm 2001), the biogeochemical significance of MSR is often considered minimal in freshwater and low-salinity systems (Stagg et al. 2017). Therefore, increased sulfate loading to low-sulfate aquatic systems with organic sediment can result in increased mercury methylation via MSR (Paranjape and Hall 2017), but strong influence of site-specific conditions need consideration in determining the potential for increased methylmercury production. These conditions are discussed in the context of the study area and project-related impacts in the following section. The study area encompassed a large area (over 150 square miles), including and surrounding the deposit area.

Potential Impacts of Project-Related Sulfate Discharge

Generally, SRBs colonize in anaerobic environments with sufficient sulfate as the primary electron receptor. If mercury is sufficiently bioavailable in these environments, only then methylmercury is formed as a co-metabolic product of the MSR process. Under this premise, project-related changes in sulfate and mercury loading (from wastewater treatment plants) to the study area surface waterbodies would not be expected to cause appreciable environmental impacts beyond the baseline with respect to increased methylmercury production. This conclusion is supported by an evaluation of the site-specific conditions and their impacts on two factors influencing mercury methylation: SRB activity, and mercury bioavailability.

Bigham et al. (2016) critically reviewed the literature on site-specific geochemical and physical parameters that may have different effects on microbial activity and mercury bioavailability. Those that are relevant for the current assessment include oxygen, temperature, selenium, iron, organic carbon, nitrate, and sulfur (discussed above).

Availability of oxygen determines the presence and activity of SRBs. SRBs are anaerobic microbes (i.e., availability of oxygen and other more favorable electron acceptors such as nitrate and iron), do not support the presence of SRB and MSR required for mercury methylation. The baseline data for sediment and surface water in the project area waterbodies are generally indicative of aerobic/oxidizing conditions that are not conducive to mercury methylation via MSR. Presence of dissolved oxygen (DO) and positive oxidation/reduction potential (ORP) in surface water and absence of acid volatile sulfide (AVS) in sediments are indicative of aerobic/oxidizing conditions that are not conducive to the activity of SRBs and mercury methylation via MSR. In the surface waterbodies in the project area, DO concentrations range from 2.22 to 18.6 mg/L and median ORP ranged from 66.8 to 154 mV in project area rivers and lakes (see EBD Tables 9.1-5 through 9.1-7, and Tables 9.1-31 and 9.1-32). In sediments collected during June to September, AVS was detected infrequently (only in 26 percent of the samples), and at low median concentrations of 0.35 mg/kg (see EBD Table 10.2-2). Based on these observations that are reflective of generally aerobic/oxidizing conditions, mercury methylation via MSR, if any, is likely to be severely limited in the study area waterbodies, regardless of project-related incremental sulfate loading.

Presence of nitrate in the study area rivers and lakes is also more indicative of aerobic conditions. Nitrate/nitrite was detected at frequencies of 60 to 88 percent, with concentrations ranging from 0.021 to 6.74 mg/L in the rivers and 0.032 to 1.19 in the lakes (see EBD Tables 9.1-5 through 9.1-7, and Tables 9.1-31 and 9.1-32). In these conditions, the SRBs, which require anaerobic conditions, are not likely to dominate the microbial population. In fact, addition of nitrate has been successful as a remedial approach to limit methylmercury production in the Onondaga Lake (Todorova et al. 2009; Matthews et al. 2013).

Mercury methylation in aquatic systems typically peaks during summer months, primarily reflecting temperature dependence of microbial activity, because they have optimal temperature range for growth, typically 27 to 30 degrees Celsius (°C) (Sawicka et al. 2012). The median temperature in the project area rivers range from 1.85 to 2.77°C, with a slightly warmer median of 11.6°C in lakes; in the summer, maximum temperatures of 15.7 to 23.5°C have been recorded in these rivers and lakes (see EBD Tables 9.1-5 through 9.1-7, and Tables 9.1-31 and 9.1-32). Therefore, increased mercury methylation via MSR may be restricted to a limited period during the summer months.

Presence of selenium is known to inhibit mercury methylation, primarily through limiting mercury bioavailability by forming insoluble selenite species (Jin et al. 1997; Chen et al. 2001; Truong et al. 2013). Selenium was detected at higher frequency and concentrations than mercury in the study area sediments: selenium was detected in 68 percent of the samples at 0.018 to 13.1 mg/kg, whereas mercury was detected in 57 percent of the samples at 0.011 to 0.42 mg/kg (see EBD Table 10.2-2). Therefore, presence of selenium may inhibit mercury methylation by limiting its bioavailability.

Iron is detected in 100 percent of the sediment samples from the study area waterbodies with concentrations ranging from 2,670 to 83,400 mg/kg (see EBD Table 10.2-2). At these levels, iron can interact with sulfur species and may decrease methylmercury production in the limited anaerobic environments that may be present in the study area waterbodies. This decrease may occur by shifting microbial assemblage from SRBs to iron-reducing microbes with less mercury methylation capacity (Lovley and Phillips 1986) and by altering mercury bioavailability via interaction with sulfur species (Mehrotra and Sedlak 2005).

Organic carbon (OC) in sediments and surface water (in dissolved form) has a major influence on metal speciation and bioavailability. Generally, OC renders mercury less bioavailable for methylation. However, in mildly sulfidic waters, dissolved OC may enhance mercury mobilization for microbes. In addition, OC (as organic matter) may encourage microbial activity (i.e., higher methylation) by providing electron donor substrate. As the total OC (TOC) range (0.13 to 32.3 percent) indicates, sporadic organic-rich locations are not uncommon given the geographic extent of the study area, but the median sediment TOC of 1.77 percent (see EBD Table 10.2-3) and dissolved OC (DOC) range of 0.16 to 8.18 mg/L (see EBD Tables 9.1-5 through 9.1-7) are generally not indicative of organic-rich conditions that generate strongly reducing environments and induce SRB activity.

Existing conditions in the study area do not indicate that sulfate is limiting the MSR. Sulfate was present in 97 percent of the samples, with concentrations ranging from 0.5 to 2600 mg/kg; mean and median sulfate concentrations were 51.8 and 9.16 mg/kg, respectively (see EBD Table 10.2-2). Similarly, sulfate was detected in almost all surface water samples, with detection frequencies of 98 to 100 percent; sulfate concentrations ranged 0.089 to 47.3 mg/L in the lakes, and 0.31 to 89.5 mg/L in the rivers (see EBD Tables 9.1-5 through 9.1-7, and Tables 9.1-31 and 9.1-32). At these concentrations, sulfate is not likely to be deficient, or the rate-limiting factor for MSR in these waterbodies. Therefore, project-related incremental change in sulfate loading is unlikely to cause appreciable change in methylmercury production via MSR. In addition, concentrations of total mercury in effluent discharges are expected to be 0.001 µg/L (which is 770 times below the ADEC water quality criterion of 0.77 µg/L). Dilution in the receiving waterbodies would further reduce mercury concentrations downstream of discharge points. At these low concentrations and anticipated geochemical interactions with various sorptive phases, mercury bioavailability would be limited for extensive formation of methylmercury.

Overall, site-specific geochemical conditions in the study area are generally not conducive to methylmercury production via MSR. In particular, existing sulfate does not appear to be insufficient such that project-related incremental sulfate loading would increase methylmercury production by triggering and/or enhancing MSR. Additionally, project-related increases in both mercury and sulfate loading would be low, and unlikely to change in baseline conditions sufficiently to cause appreciable environmental impact due to mercury methylation.

K4.24.5 Instream Flow Modeling Results

The following figures and tables provide detailed results of the instream flow modeling for various life stages of Pacific salmon and resident salmonids during pre-mine, mine operations, and mine closure periods under wet, average, and dry water years. See PLP 2018-RFI 048 and PLP 2019-RFI 147 for descriptions of fish habitat modeling assumptions and methodologies.

The instream flow modeling produced estimates of the area (in acres) of suitable habitat for each species and life stage by mainstem stream reach of the Koktuli River (KR), NFK, SFK, and UTC, as well as for one principal tributary to each of the three subbasins. The estimated amounts of suitable habitat, as well as the percent change from pre-project to either mine operations or mine closure, are listed in Table K4.24-1 for spawning by anadromous and resident salmonids; Table K4.24-2 for juvenile rearing by anadromous and resident salmonids; and Table K4.24-3 for adult rearing by resident salmonids. These tables show the magnitude of both increases and decreases in suitable habitat under each operational period and water year scenario. Table K4.24-1, Table K4.24-2, and Table K4.24-3 show decreases in habitat that exceed 2 percent in red bold font; all other changes are either less than 2 percent or represent predicted increases in suitable habitat. It can be seen that most of the decreases exceeding 2 percent would be expected to occur in Tributaries NFK 1.190 and SFK 1.190. Also note that with few exceptions, suitable habitat in UTC would not be expected to change more than 2 percent. Section 4.24, Fish Values, summarizes the overall results presented in Table K4.24-1, Table K4.24-2, and Table K4.24-3, and the example figures shown below.

Figure K4.24-1 illustrates the frequency distribution of percentage changes in suitable spawning habitat for all Pacific salmon combined under an average water year. This figure illustrates that most predicted changes in the amount of suitable habitat would be expected to be less than 2 percent from pre-mine conditions, and that most changes would be expected to be positive (i.e., suitable habitat would increase during operations and closure). Similar results are seen for juvenile rearing of Pacific salmon, and for spawning, juvenile rearing, and adult rearing by resident salmonid species (Table K4.24-2 and Table K4.24-3). All three tables contain equivalent estimates for the remaining water years (dry and wet), and for the remaining species and life stages that were modeled.

Figure K4.24-2 uses data in Table K4.24-1 to illustrate the relationship between stream reach and changes in suitable spawning habitat for Chinook salmon under different project scenarios and during an average water year. Note that suitable habitat increases in the downstream direction, and those reaches showing larger changes in habitat (e.g., tributaries, NFK-D, SFK-C) also show that relatively little suitable habitat exists even under pre-mine conditions. Similar results are seen under wet- and dry-year scenarios for juvenile rearing of salmon species, and for spawning, juvenile rearing, and adult rearing by resident salmonid species (Table K4.24-2, and Table K4.24-3).

To better visualize the relationship between stream reach and predicted changes in suitable habitat for each species and life stage, the estimated changes in suitable habitat by stream reach during an average water year scenario are depicted in maps using a color-coding system (see Table K4.24-1, Table K4.24-2, and Table K4.24-3 for values representing wet and dry year scenarios). Figure K4.24-3 illustrates that large, predicted decreases in the amount of suitable habitat would be largely restricted to the tributaries NFK 1.190 and SFK 1.190, and that changes in lower reaches would minor (yellow lines) or are positive (blue and green lines) in value. Note that the UTC is not portrayed in these maps because only 3 of the 84 UTC estimates for spawning showed decreases exceeding 2 percent, and none of the UTC estimates for juvenile or adult rearing showed decreases exceeding that value (Table K4.24-1, Table K4.24-2, and Table K4.24-3). Also note that predicted changes in NFK-D would only extend up to the project discharge at tributary NFK 1.200; the remainder of mainstem reach NFK-D would not be subject to changes in streamflow or flow-related changes in suitable habitat. Reaches upstream of NFK-D and SFK-C and other tributaries to the NFK and SFK were not modeled, and are therefore not shown in the maps.

Figure K4.24-1: Frequency of Percentage Change in Suitable Spawning Habitat from Pre-Mine to Mine Operations or Mine Closure During an Average Water Year for Pacific Salmon

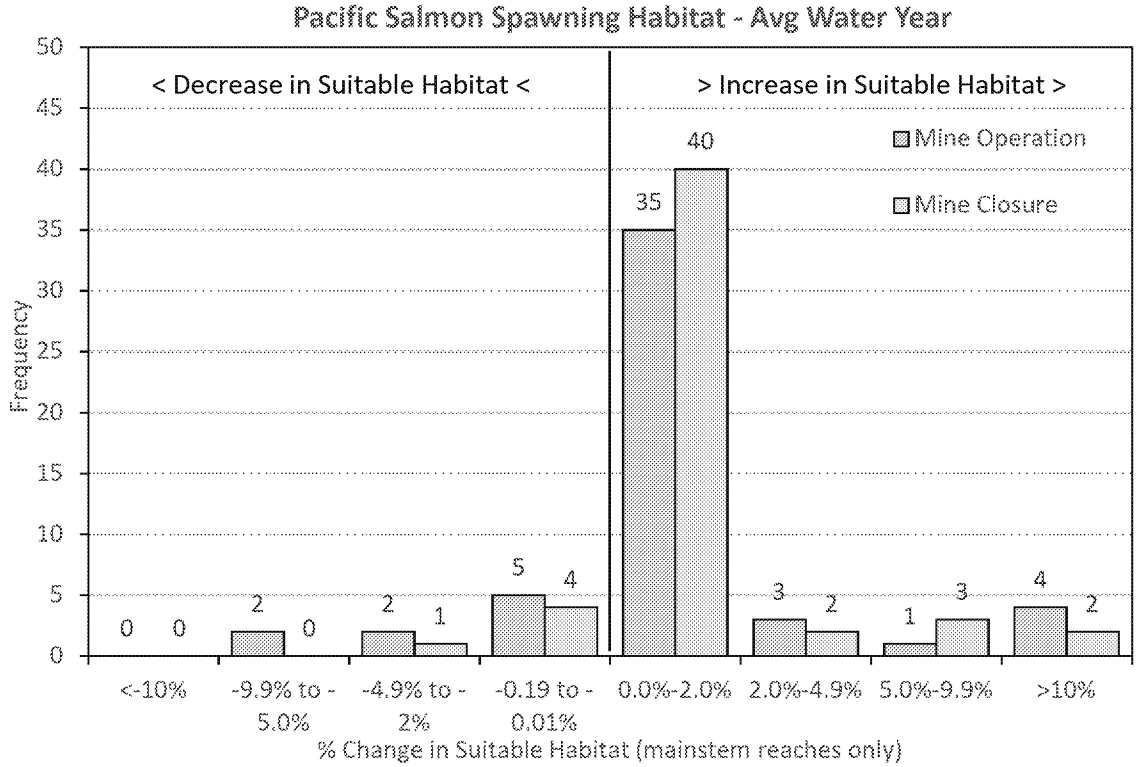

Figure K4.24-2: Predicted Changes in Suitable Habitat for Chinook Salmon Spawning During an Average Water Year According to Reach and Mine Operational Period

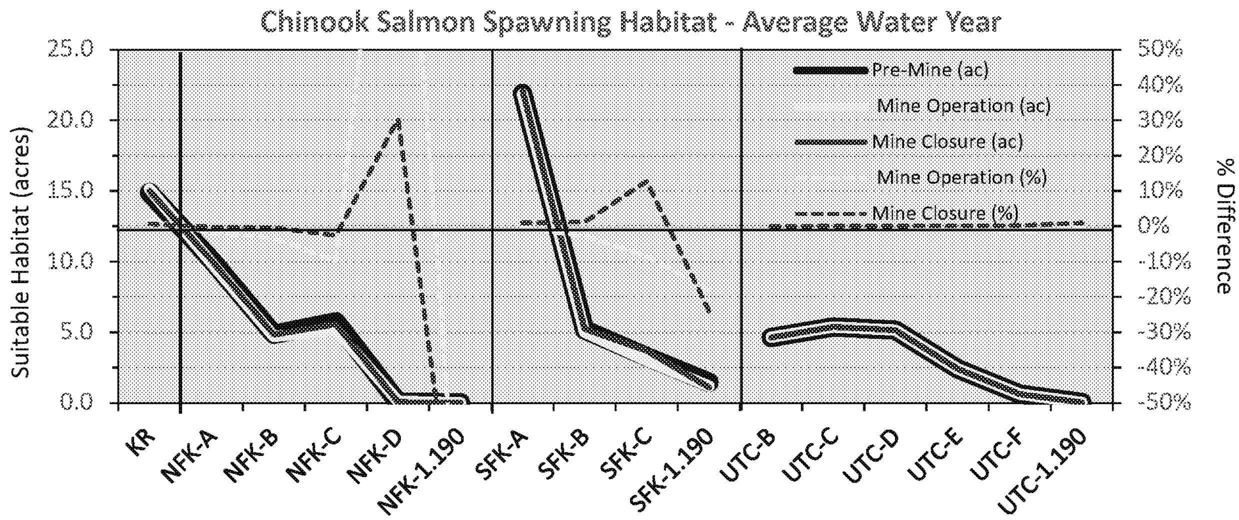

Table K4.24-1: Predicted Quantity (acres) of Suitable Spawning Habitat by Species, Reach, Water Year, and Mine Operational Period

Basin-Reach	Spawning—Wet Year					Spawning—Average Year					Spawning—Dry Year				
	Pre-Mine	Mine Operations	Mine Closure	Mine Operations	Mine Closure	Pre-Mine	Mine Operations	Mine Closure	Mine Operations	Mine Closure	Pre-Mine	Mine Operations	Mine Closure	Mine Operations	Mine Closure
	(acres)	(acres)	(acres)	(% diff)	(% diff)	(acres)	(acres)	(acres)	(% diff)	(% diff)	(acres)	(acres)	(acres)	(% diff)	(% diff)
Chinook Salmon															
KR	13.80	13.98	13.87	1.3%	0.5%	14.89	15.15	14.99	1.7%	0.7%	11.96	11.72	11.92	**-2.0%**	-0.4%
NFK-A	11.42	11.29	11.49	-1.1%	0.6%	10.08	9.89	10.05	-1.8%	-0.2%	6.57	6.47	6.45	-1.5%	-1.9%
NFK-B	5.74	5.67	5.81	-1.1%	1.3%	4.85	4.69	4.83	**-3.3%**	-0.5%	1.96	1.81	1.85	**-7.8%**	**-5.4%**
NFK-C	7.54	6.96	7.59	**-7.6%**	0.7%	5.73	5.17	5.58	**-9.9%**	**-2.6%**	2.57	2.34	2.33	**-9.0%**	**-9.3%**
NFK-D	0.08	0.17	0.09	112.4%	15.1%	0.05	0.12	0.06	143.5%	30.3%	0.02	0.07	0.03	274.6%	50.7%
NFK-1.190	0.02	0.00	0.00	**-100.0%**	**-100.0%**	0.01	0.00	0.00	**-100.0%**	**-100.0%**	0.00	0.00	0.00	**-100.0%**	**-100.0%**
SFK-A	19.65	19.82	20.05	0.9%	2.0%	21.90	21.84	22.10	-0.3%	0.9%	9.61	9.41	9.89	**-2.1%**	2.9%
SFK-B	4.93	4.97	5.05	0.9%	2.4%	5.17	5.02	5.23	**-2.9%**	1.2%	0.70	0.72	0.75	1.8%	6.6%
SFK-C	3.37	3.35	3.47	-0.8%	3.0%	3.28	3.00	3.69	**-8.5%**	12.7%	0.13	0.06	0.27	**-51.2%**	113.5%
SFK-1.190	2.02	1.84	1.76	**-8.5%**	**-12.7%**	1.45	1.19	1.10	**-18.1%**	**-24.1%**	0.13	0.07	0.07	**-42.5%**	**-47.5%**
UTC-B	3.78	3.78	3.78	0.0%	0.0%	4.64	4.64	4.63	0.1%	-0.1%	6.38	6.40	6.38	0.2%	-0.1%
UTC-C	4.85	4.85	4.85	0.1%	0.0%	5.38	5.38	5.38	0.1%	0.1%	4.51	4.50	4.52	-0.3%	0.2%
UTC-D	5.48	5.48	5.48	0.1%	0.0%	5.15	5.15	5.15	-0.1%	0.1%	3.30	3.28	3.31	-0.6%	0.1%
UTC-E	3.71	3.71	3.72	0.0%	0.1%	2.41	2.40	2.41	-0.3%	0.1%	1.19	1.18	1.19	-1.3%	0.1%
UTC-F	1.01	1.01	1.01	-0.2%	0.3%	0.63	0.62	0.63	-1.7%	0.2%	0.35	0.30	0.34	**-15.3%**	**-3.8%**
UTC-1.190	0.04	0.04	0.04	0.0%	0.8%	0.04	0.04	0.04	0.0%	1.0%	0.02	0.02	0.02	0.5%	4.4%
Coho Salmon															
KR	31.27	31.59	31.33	1.0%	0.2%	35.32	35.58	35.42	0.7%	0.3%	39.91	40.19	39.97	0.7%	0.2%
NFK-A	14.17	14.06	14.10	-0.8%	-0.5%	12.87	12.73	12.74	-1.1%	-1.0%	11.26	11.22	11.14	-0.3%	-1.0%
NFK-B	6.17	6.31	6.21	2.1%	0.6%	5.95	6.04	5.96	1.5%	0.1%	5.80	5.90	5.74	1.7%	-1.1%
NFK-C	12.04	12.25	12.05	1.7%	0.1%	11.75	11.78	11.61	0.3%	-1.2%	10.66	10.51	10.32	-1.4%	**-3.2%**
NFK-D	1.07	1.28	1.09	20.3%	1.7%	0.95	1.20	0.98	26.3%	3.3%	0.75	1.04	0.78	39.1%	4.7%
NFK-1.190	0.02	0.00	0.00	**-98.6%**	**-98.6%**	0.01	0.00	0.00	**-98.8%**	**-98.8%**	0.01	0.00	0.00	**-98.5%**	**-98.5%**
SFK-A	20.17	20.20	20.20	0.2%	0.2%	17.23	17.22	17.43	-0.1%	1.1%	17.13	16.96	17.40	-1.0%	1.6%
SFK-B	4.67	4.70	4.73	0.7%	1.4%	3.58	3.61	3.65	0.7%	1.8%	2.89	2.82	3.00	**-2.4%**	3.9%
SFK-C	6.62	6.68	6.72	1.0%	1.5%	4.87	4.94	5.30	1.5%	9.0%	4.46	4.43	5.27	-0.7%	18.2%
SFK-1.190	3.53	3.14	3.04	**-11.0%**	**-14.0%**	2.33	2.02	1.98	**-13.5%**	**-15.2%**	1.57	1.29	1.24	**-17.6%**	**-20.8%**
UTC-B	3.07	3.07	3.07	0.0%	0.0%	3.32	3.32	3.32	0.0%	-0.1%	3.48	3.49	3.48	0.1%	0.0%
UTC-C	5.97	5.97	5.97	0.0%	0.0%	5.92	5.92	5.92	0.0%	0.0%	6.00	6.00	6.00	0.0%	0.0%
UTC-D	8.51	8.52	8.51	0.1%	0.0%	9.71	9.72	9.72	0.1%	0.1%	10.85	10.86	10.86	0.1%	0.0%
UTC-E	9.89	9.91	9.90	0.2%	0.1%	10.27	10.29	10.29	0.2%	0.1%	8.85	8.84	8.85	-0.1%	0.0%

Table K4.24-1: Predicted Quantity (acres) of Suitable Spawning Habitat by Species, Reach, Water Year, and Mine Operational Period

Basin-Reach	Spawning—Wet Year					Spawning—Average Year					Spawning—Dry Year				
	Pre-Mine (acres)	Mine Operations (acres)	Mine Closure (acres)	Mine Operations (% diff)	Mine Closure (% diff)	Pre-Mine (acres)	Mine Operations (acres)	Mine Closure (acres)	Mine Operations (% diff)	Mine Closure (% diff)	Pre-Mine (acres)	Mine Operations (acres)	Mine Closure (acres)	Mine Operations (% diff)	Mine Closure (% diff)
UTC-F	4.51	4.54	4.50	0.7%	-0.2%	4.36	4.39	4.37	0.7%	0.3%	3.79	3.76	3.79	-0.8%	0.0%
UTC-1.190	0.32	0.32	0.32	0.0%	0.2%	0.32	0.32	0.32	0.0%	0.2%	0.31	0.31	0.31	0.0%	0.3%
Sockeye Salmon															
KR	32.21	32.63	32.27	1.3%	0.2%	34.41	34.90	34.46	1.4%	0.1%	42.16	42.51	42.20	0.8%	0.1%
NFK-A	13.05	13.15	13.07	0.7%	0.2%	13.51	13.61	13.55	0.7%	0.3%	12.28	12.19	12.24	-0.7%	-0.3%
NFK-B	5.54	5.78	5.61	4.3%	1.2%	5.94	6.22	6.04	4.6%	1.6%	6.90	6.98	6.93	1.2%	0.4%
NFK-C	11.70	12.30	11.89	5.1%	1.6%	12.53	13.20	12.77	5.3%	1.9%	12.98	13.09	13.00	0.8%	0.1%
NFK-D	1.55	1.73	1.61	11.8%	4.1%	1.27	1.73	1.34	36.3%	6.1%	1.21	1.70	1.29	40.6%	7.2%
NFK-1.190	0.02	0.00	0.00	**-98.8%**	**-98.8%**	0.02	0.00	0.00	**-99.0%**	**-99.0%**	0.01	0.00	0.00	**-98.9%**	**-98.9%**
SFK-A	28.18	28.29	28.15	0.4%	-0.1%	28.98	29.04	29.05	0.2%	0.2%	30.84	30.86	30.97	0.1%	0.4%
SFK-B	8.45	8.39	8.44	-0.7%	0.0%	8.74	8.79	8.80	0.6%	0.6%	8.02	7.76	8.28	**-3.2%**	3.3%
SFK-C	9.45	9.61	9.33	1.7%	-1.2%	9.94	9.93	10.09	-0.1%	1.5%	9.22	8.76	9.95	**-5.0%**	7.9%
SFK-1.190	5.23	4.87	4.76	**-6.8%**	**-9.1%**	5.53	5.06	4.87	**-8.6%**	**-11.9%**	4.15	3.38	3.23	**-18.4%**	**-22.1%**
UTC-B	6.64	6.64	6.64	0.0%	0.0%	7.50	7.51	7.50	0.0%	0.0%	8.05	8.05	8.04	0.0%	0.0%
UTC-C	7.05	7.05	7.05	0.0%	0.0%	7.37	7.37	7.37	0.0%	0.0%	7.45	7.45	7.45	0.0%	0.0%
UTC-D	11.79	11.79	11.79	0.0%	0.0%	13.60	13.60	13.59	0.0%	0.0%	13.64	13.64	13.64	0.0%	0.0%
UTC-E	10.31	10.31	10.31	0.0%	0.0%	10.85	10.86	10.86	0.1%	0.0%	10.04	10.03	10.05	-0.1%	0.1%
UTC-F	5.21	5.17	5.21	-0.6%	0.0%	4.94	4.94	4.94	0.1%	0.1%	4.11	4.06	4.13	-1.3%	0.3%
UTC-1.190	0.97	0.97	0.97	0.1%	-0.2%	1.04	1.04	1.04	0.0%	-0.3%	1.01	1.01	1.00	0.0%	-0.2%
Chum Salmon															
KR	29.00	29.27	28.88	0.9%	-0.4%	32.22	32.67	32.27	1.4%	0.2%	38.23	38.07	38.17	-0.4%	-0.2%
NFK-A	23.96	24.31	24.06	1.5%	0.4%	24.28	24.46	24.35	0.7%	0.3%	22.82	22.78	22.75	-0.2%	-0.3%
NFK-B	11.68	12.22	11.76	4.7%	0.7%	12.43	12.90	12.58	3.7%	1.2%	12.50	12.37	12.39	-1.1%	-0.9%
NFK-C	18.52	19.55	18.75	5.6%	1.3%	19.32	20.00	19.59	3.5%	1.4%	19.27	19.25	18.99	-0.1%	-1.4%
NFK-D	2.70	3.18	2.85	17.9%	5.5%	2.33	3.00	2.49	28.8%	7.1%	1.76	2.72	2.02	54.2%	14.5%
NFK-1.190	0.07	0.00	0.00	**-95.9%**	**-95.9%**	0.06	0.00	0.00	**-96.0%**	**-96.0%**	0.04	0.00	0.00	**-96.2%**	**-96.2%**
SFK-A	36.51	36.71	36.63	0.5%	0.3%	39.68	39.84	39.73	0.4%	0.1%	38.76	38.53	39.15	-0.6%	1.0%
SFK-B	8.02	8.21	8.20	2.4%	2.2%	10.46	10.60	10.53	1.3%	0.7%	6.35	6.39	6.48	0.6%	2.2%
SFK-C	7.68	7.92	7.79	3.2%	1.4%	9.78	9.86	9.86	0.8%	0.8%	2.42	2.02	3.98	**-16.5%**	64.1%
SFK-1.190	5.41	5.45	5.40	0.6%	-0.2%	5.63	5.30	5.17	**-5.9%**	**-8.2%**	3.09	2.56	2.47	**-17.2%**	**-20.2%**
UTC-B	7.80	7.80	7.79	0.1%	0.0%	9.12	9.12	9.11	0.1%	-0.1%	11.31	11.33	11.30	0.2%	-0.1%
UTC-C	9.61	9.61	9.61	0.0%	0.0%	11.08	11.09	11.08	0.1%	-0.1%	13.30	13.31	13.30	0.1%	0.0%

Table K4.24-1: Predicted Quantity (acres) of Suitable Spawning Habitat by Species, Reach, Water Year, and Mine Operational Period

Basin-Reach	Spawning—Wet Year					Spawning—Average Year					Spawning—Dry Year				
	Pre-Mine	Mine Operations	Mine Closure	Mine Operations	Mine Closure	Pre-Mine	Mine Operations	Mine Closure	Mine Operations	Mine Closure	Pre-Mine	Mine Operations	Mine Closure	Mine Operations	Mine Closure
	(acres)	(acres)	(acres)	(% diff)	(% diff)	(acres)	(acres)	(acres)	(% diff)	(% diff)	(acres)	(acres)	(acres)	(% diff)	(% diff)
UTC-D	11.80	11.81	11.80	0.1%	0.0%	15.61	15.63	15.61	0.1%	0.0%	16.67	16.66	16.68	-0.1%	0.0%
UTC-E	11.76	11.77	11.76	0.1%	0.0%	12.36	12.37	12.37	0.1%	0.1%	10.81	10.77	10.82	-0.3%	0.1%
UTC-F	5.22	5.23	5.22	0.2%	0.0%	5.04	5.04	5.05	-0.1%	0.2%	4.56	4.43	4.54	**-2.8%**	-0.4%
UTC-1.190	0.53	0.53	0.53	0.0%	-0.7%	0.55	0.55	0.54	0.0%	-0.8%	0.61	0.61	0.61	0.0%	0.1%
Rainbow Trout															
KR	19.91	19.82	19.80	-0.4%	-0.5%	25.61	25.97	25.75	1.4%	0.6%	26.67	27.19	26.65	1.9%	-0.1%
NFK-A	15.00	16.50	15.18	10.0%	1.2%	18.21	19.19	18.38	5.4%	0.9%	22.49	22.87	22.48	1.7%	-0.1%
NFK-B	5.04	5.42	5.09	7.6%	1.0%	5.77	6.27	5.88	8.6%	1.8%	7.27	7.60	7.29	4.7%	0.3%
NFK-C	9.98	11.72	10.28	17.4%	3.0%	11.37	12.67	11.59	11.5%	2.0%	14.00	14.54	14.01	3.9%	0.1%
NFK-D	1.99	1.97	1.99	-1.0%	0.0%	1.82	2.13	1.82	17.3%	0.0%	1.78	2.35	1.78	32.2%	-0.1%
NFK-1.190	0.05	0.00	0.00	**-97.5%**	**-97.5%**	0.04	0.00	0.00	**-97.7%**	**-97.7%**	0.04	0.00	0.00	**-99.1%**	**-99.1%**
SFK-A	21.69	21.84	21.99	0.7%	1.3%	24.45	24.57	24.56	0.5%	0.4%	28.95	29.06	28.93	0.4%	-0.1%
SFK-B	4.24	4.36	4.36	2.9%	2.9%	6.17	6.30	6.34	2.1%	2.7%	8.47	8.36	8.60	-1.2%	1.6%
SFK-C	2.98	3.13	3.22	5.1%	8.2%	4.12	4.32	4.31	4.8%	4.6%	5.77	5.78	5.48	0.2%	**-5.0%**
SFK-1.190	3.04	3.11	3.14	2.6%	3.3%	3.59	3.66	3.66	1.8%	2.0%	4.68	4.39	4.30	**-6.1%**	**-8.1%**
UTC-B	5.16	5.17	5.16	0.1%	0.0%	7.03	7.03	7.03	0.0%	0.0%	8.43	8.44	8.43	0.0%	0.0%
UTC-C	4.26	4.27	4.26	0.0%	0.0%	5.06	5.06	5.06	0.0%	0.0%	5.65	5.65	5.65	0.0%	0.0%
UTC-D	5.21	5.21	5.21	0.2%	0.1%	9.15	9.16	9.15	0.1%	0.0%	12.18	12.19	12.19	0.1%	0.1%
UTC-E	5.19	5.20	5.20	0.2%	0.1%	8.14	8.15	8.14	0.1%	0.0%	10.54	10.55	10.55	0.1%	0.1%
UTC-F	5.07	5.10	5.08	0.5%	0.2%	5.01	5.06	5.01	0.9%	0.0%	5.53	5.50	5.51	-0.5%	-0.4%
UTC-1.190	0.95	0.95	0.94	0.0%	-0.6%	0.82	0.82	0.81	0.0%	-0.5%	1.03	1.03	1.03	0.0%	0.1%
Dolly Varden															
KR	36.98	37.34	36.96	1.0%	-0.1%	40.48	41.07	40.50	1.5%	0.1%	57.08	57.77	57.21	1.2%	0.2%
NFK-A	28.31	28.72	28.38	1.4%	0.3%	30.95	31.01	30.88	0.2%	-0.2%	28.29	28.10	28.10	-0.7%	-0.7%
NFK-B	10.28	10.64	10.38	3.5%	0.9%	11.93	12.33	12.07	3.3%	1.1%	12.60	12.71	12.57	0.9%	-0.2%
NFK-C	19.58	20.76	19.87	6.0%	1.5%	22.64	23.24	22.77	2.7%	0.5%	22.26	22.25	22.10	-0.1%	-0.7%
NFK-D	3.13	3.17	3.13	1.2%	0.0%	3.11	3.41	3.11	9.8%	0.0%	2.79	3.36	2.79	20.2%	0.0%
NFK-1.190	0.05	0.00	0.00	**-97.4%**	**-97.4%**	0.04	0.00	0.00	**-97.8%**	**-97.8%**	0.03	0.00	0.00	**-98.2%**	**-98.2%**
SFK-A	39.45	39.62	39.38	0.4%	-0.2%	42.70	42.89	42.67	0.4%	-0.1%	43.57	43.45	44.04	-0.3%	1.1%
SFK-B	9.14	9.29	9.14	1.6%	-0.1%	11.21	11.38	11.17	1.6%	-0.3%	9.35	9.26	9.66	-1.0%	3.3%
SFK-C	8.82	9.12	8.48	3.4%	**-3.9%**	11.07	11.36	10.73	2.6%	**-3.1%**	8.78	8.67	10.21	-1.3%	16.3%
SFK-1.190	6.37	6.45	6.46	1.3%	1.4%	7.21	7.16	7.10	-0.8%	-1.6%	5.76	5.23	5.17	**-9.2%**	**-10.3%**

Table K4.24-1: Predicted Quantity (acres) of Suitable Spawning Habitat by Species, Reach, Water Year, and Mine Operational Period

Basin-Reach	Spawning—Wet Year					Spawning—Average Year					Spawning—Dry Year				
	Pre-Mine (acres)	Mine Operations (acres)	Mine Closure (acres)	Mine Operations (% diff)	Mine Closure (% diff)	Pre-Mine (acres)	Mine Operations (acres)	Mine Closure (acres)	Mine Operations (% diff)	Mine Closure (% diff)	Pre-Mine (acres)	Mine Operations (acres)	Mine Closure (acres)	Mine Operations (% diff)	Mine Closure (% diff)
UTC-B	8.39	8.39	8.39	0.0%	0.0%	9.02	9.02	9.02	0.0%	0.0%	10.44	10.44	10.44	0.0%	0.0%
UTC-C	8.23	8.23	8.23	0.0%	0.0%	8.70	8.70	8.70	0.0%	0.0%	9.34	9.35	9.34	0.0%	0.0%
UTC-D	12.87	12.87	12.87	0.0%	0.0%	13.82	13.83	13.83	0.1%	0.1%	18.16	18.18	18.17	0.1%	0.0%
UTC-E	13.02	13.03	13.02	0.0%	0.0%	13.59	13.61	13.60	0.1%	0.1%	14.97	14.98	14.98	0.0%	0.0%
UTC-F	7.97	7.98	7.99	0.1%	0.2%	7.19	7.26	7.25	0.9%	0.8%	7.11	7.04	7.14	-1.0%	0.3%
UTC-1.190	1.21	1.21	1.21	0.0%	-0.2%	1.24	1.24	1.23	0.0%	-0.1%	1.24	1.24	1.24	0.0%	-0.1%
Arctic Grayling															
KR	46.68	47.23	47.00	1.2%	0.7%	52.53	53.76	53.15	2.3%	1.2%	63.33	64.48	63.75	1.8%	0.7%
NFK-A	18.25	18.82	18.41	3.1%	0.9%	12.71	13.97	13.13	9.8%	3.3%	17.13	17.57	17.25	2.6%	0.7%
NFK-B	6.23	6.33	6.29	1.6%	0.9%	4.78	5.48	5.04	14.6%	5.4%	7.23	7.62	7.38	5.4%	2.1%
NFK-C	13.82	13.99	13.96	1.2%	1.0%	9.06	12.02	9.92	32.7%	9.5%	13.58	15.00	13.86	10.4%	2.1%
NFK-D	2.13	2.51	2.29	17.7%	7.2%	1.23	1.93	1.40	57.1%	13.4%	1.12	2.14	1.34	90.3%	18.9%
NFK-1.190	0.04	0.00	0.00	**-100.0%**	**-100.0%**	0.02	0.00	0.00	**-100.0%**	**-100.0%**	0.00	0.00	0.00	**-100.0%**	**-100.0%**
SFK-A	28.10	27.84	27.99	-0.9%	-0.4%	25.21	24.83	25.36	-1.5%	0.6%	29.05	29.12	29.71	0.2%	2.2%
SFK-B	5.47	5.47	5.46	-0.1%	-0.2%	5.05	4.88	4.99	**-3.2%**	-1.2%	6.83	6.89	7.15	0.8%	4.6%
SFK-C	6.52	6.43	6.35	-1.4%	**-2.7%**	4.47	4.51	5.24	1.0%	17.2%	7.78	7.85	8.94	0.8%	14.9%
SFK-1.190	3.40	3.38	3.49	-0.7%	2.6%	2.03	1.94	1.94	**-4.5%**	**-4.3%**	2.32	1.87	1.80	**-19.2%**	**-22.4%**
UTC-B	5.15	5.15	5.15	0.1%	0.0%	5.25	5.26	5.25	0.1%	0.0%	5.54	5.54	5.54	0.0%	0.0%
UTC-C	6.78	6.78	6.78	0.1%	0.0%	6.89	6.90	6.89	0.1%	0.0%	7.43	7.44	7.43	0.0%	0.0%
UTC-D	10.06	10.09	10.06	0.3%	-0.1%	12.16	12.20	12.17	0.3%	0.1%	16.08	16.11	16.09	0.2%	0.0%
UTC-E	10.73	10.76	10.71	0.4%	-0.1%	12.92	12.96	12.92	0.3%	0.0%	15.41	15.42	15.40	0.1%	0.0%
UTC-F	5.44	5.51	5.40	1.3%	-0.7%	6.56	6.62	6.54	0.9%	-0.4%	7.26	7.18	7.18	-1.1%	-1.1%
UTC-1.190	0.65	0.65	0.65	0.0%	0.5%	0.65	0.65	0.65	0.0%	0.5%	0.59	0.59	0.60	0.1%	0.9%

Note: Percent decreases in habitat from pre-mine period exceeding 2 percent are shown in bold font.

Source: PLP 2019-RFI 149

Table K4.24-2: Predicted Quantity (acres) of Suitable Juvenile Rearing Habitat by Species, Reach, Water Year, and Mine Operational Period

Basin-Reach	Juvenile Rearing—Wet Year					Juvenile Rearing—Average Year					Juvenile Rearing—Dry Year				
	Pre-Mine	Mine Operations	Mine Closure	Mine Operations	Mine Closure	Pre-Mine	Mine Operations	Mine Closure	Mine Operations	Mine Closure	Pre-Mine	Mine Operations	Mine Closure	Mine Operations	Mine Closure
	(acres)	(acres)	(acres)	(% diff)	(% diff)	(acres)	(acres)	(acres)	(% diff)	(% diff)	(acres)	(acres)	(acres)	(% diff)	(% diff)
Chinook Salmon															
KR	14.40	14.67	14.56	1.8%	1.1%	15.01	14.97	15.01	-0.3%	0.0%	14.69	14.79	14.75	0.6%	0.4%
NFK-A	5.03	5.06	5.04	0.5%	0.2%	4.67	4.80	4.71	2.7%	0.8%	4.31	4.64	4.44	7.8%	3.0%
NFK-B	4.68	4.63	4.67	-1.0%	-0.3%	3.85	3.95	3.84	2.7%	-0.2%	4.15	4.28	4.19	2.9%	0.9%
NFK-C	5.77	5.79	5.75	0.5%	-0.2%	5.08	5.45	5.13	7.3%	0.9%	4.77	5.46	5.09	14.4%	6.6%
NFK-D	0.86	0.99	0.93	15.5%	8.1%	0.72	0.95	0.84	32.5%	16.4%	0.71	0.95	0.82	34.1%	14.8%
NFK-1.190	0.05	0.01	0.01	**-79.6%**	**-79.6%**	0.05	0.01	0.01	**-83.6%**	**-83.6%**	0.05	0.01	0.01	**-78.4%**	**-78.4%**
SFK-A	7.54	7.54	7.64	0.0%	1.4%	7.86	7.72	7.90	-1.7%	0.5%	8.94	8.94	9.01	0.0%	0.8%
SFK-B	3.75	3.76	3.80	0.3%	1.3%	3.81	3.77	3.86	-1.0%	1.4%	4.25	4.24	4.32	-0.2%	1.8%
SFK-C	4.15	4.42	4.45	6.6%	7.3%	4.34	4.53	4.66	4.6%	7.5%	5.96	6.33	6.45	6.3%	8.4%
SFK-1.190	1.20	1.10	1.08	**-7.9%**	**-10.0%**	0.97	0.85	0.83	**-12.3%**	**-14.4%**	0.97	0.83	0.80	**-15.2%**	**-18.2%**
UTC-B	1.44	1.44	1.44	-0.1%	-0.1%	1.40	1.40	1.40	-0.1%	-0.1%	1.49	1.49	1.49	-0.1%	-0.1%
UTC-C	4.39	4.39	4.39	0.0%	0.0%	4.17	4.17	4.17	-0.1%	-0.1%	4.36	4.36	4.36	0.0%	0.0%
UTC-D	8.20	8.22	8.21	0.3%	0.1%	8.87	8.87	8.87	0.0%	0.0%	8.63	8.65	8.64	0.3%	0.1%
UTC-E	4.90	4.92	4.91	0.4%	0.2%	5.54	5.56	5.55	0.3%	0.1%	5.02	5.04	5.03	0.4%	0.2%
UTC-F	2.63	2.64	2.64	0.2%	0.1%	2.62	2.63	2.61	0.3%	-0.4%	2.61	2.62	2.62	0.3%	0.1%
UTC-1.190	0.05	0.05	0.05	-0.1%	0.9%	0.04	0.04	0.04	0.0%	1.0%	0.04	0.04	0.04	-0.1%	1.0%
Coho Salmon															
KR	12.03	12.12	12.12	0.8%	0.7%	11.47	11.36	11.45	-0.9%	-0.1%	11.50	11.51	11.52	0.1%	0.2%
NFK-A	6.21	6.20	6.21	-0.3%	-0.1%	6.03	6.11	6.08	1.3%	0.8%	5.50	5.97	5.70	8.6%	3.7%
NFK-B	6.01	5.94	5.99	-1.2%	-0.4%	5.09	5.22	5.11	2.5%	0.2%	5.31	5.54	5.40	4.2%	1.6%
NFK-C	7.41	7.52	7.43	1.4%	0.2%	7.03	7.41	7.09	5.4%	1.0%	6.31	7.29	6.87	15.4%	8.8%
NFK-D	1.37	1.41	1.46	3.3%	6.6%	1.21	1.47	1.42	22.3%	17.8%	1.13	1.41	1.31	25.5%	16.0%
NFK-1.190	0.07	0.02	0.02	**-73.6%**	**-73.6%**	0.07	0.01	0.01	**-79.9%**	**-79.9%**	0.07	0.02	0.02	**-72.9%**	**-72.9%**
SFK-A	5.34	5.35	5.41	0.2%	1.2%	5.71	5.60	5.68	-1.8%	-0.4%	5.76	5.78	5.75	0.3%	-0.1%
SFK-B	2.99	2.98	3.02	-0.3%	0.9%	3.09	3.07	3.09	-0.6%	-0.1%	3.00	3.00	2.99	-0.1%	-0.4%
SFK-C	3.16	3.59	3.61	13.7%	14.5%	3.89	4.26	4.18	9.2%	7.4%	5.71	6.16	5.75	7.9%	0.7%
SFK-1.190	1.04	0.99	0.98	**-5.2%**	**-5.8%**	1.03	0.94	0.93	**-8.8%**	**-9.8%**	1.14	1.05	1.03	**-8.4%**	**-9.8%**
UTC-B	1.15	1.15	1.15	-0.1%	-0.1%	0.95	0.95	0.95	-0.2%	-0.1%	1.01	1.01	1.01	-0.1%	-0.1%
UTC-C	4.07	4.06	4.06	-0.2%	-0.1%	3.59	3.58	3.58	-0.2%	-0.1%	3.88	3.87	3.88	-0.2%	-0.1%
UTC-D	8.31	8.33	8.32	0.2%	0.1%	8.74	8.74	8.74	0.0%	0.0%	8.54	8.56	8.55	0.2%	0.1%
UTC-E	5.41	5.44	5.42	0.4%	0.2%	6.09	6.11	6.10	0.2%	0.1%	5.61	5.64	5.62	0.4%	0.2%
UTC-F	3.57	3.59	3.59	0.5%	0.3%	3.55	3.56	3.51	0.3%	-1.2%	3.57	3.60	3.58	0.8%	0.3%

Table K4.24-2: Predicted Quantity (acres) of Suitable Juvenile Rearing Habitat by Species, Reach, Water Year, and Mine Operational Period

Basin-Reach	Juvenile Rearing—Wet Year					Juvenile Rearing—Average Year					Juvenile Rearing—Dry Year				
	Pre-Mine	Mine Operations	Mine Closure	Mine Operations	Mine Closure	Pre-Mine	Mine Operations	Mine Closure	Mine Operations	Mine Closure	Pre-Mine	Mine Operations	Mine Closure	Mine Operations	Mine Closure
	(acres)	(acres)	(acres)	(% diff)	(% diff)	(acres)	(acres)	(acres)	(% diff)	(% diff)	(acres)	(acres)	(acres)	(% diff)	(% diff)
UTC-1.190	0.12	0.12	0.13	0.0%	0.2%	0.12	0.12	0.12	0.0%	0.1%	0.12	0.12	0.12	0.0%	0.1%
Sockeye Salmon															
KR	14.31	14.21	14.30	-0.7%	0.0%	12.91	12.92	12.94	0.1%	0.2%	12.92	12.83	12.92	-0.7%	0.0%
NFK-A	4.73	4.75	4.74	0.5%	0.3%	4.40	4.52	4.46	2.9%	1.4%	4.59	4.77	4.67	4.0%	1.7%
NFK-B	6.58	6.48	6.56	-1.5%	-0.2%	5.61	5.78	5.71	3.0%	1.8%	5.90	5.96	5.97	0.9%	1.2%
NFK-C	3.67	3.89	3.72	5.9%	1.3%	3.65	4.13	3.85	13.2%	5.6%	4.32	4.74	4.47	9.7%	3.3%
NFK-D	0.39	0.37	0.46	**-4.0%**	19.0%	0.46	0.51	0.58	11.2%	26.3%	0.63	0.58	0.70	**-7.5%**	11.6%
NFK-1.190	0.03	0.02	0.02	**-40.5%**	**-40.5%**	0.04	0.01	0.01	**-59.0%**	**-59.0%**	0.03	0.01	0.01	**-70.2%**	**-70.2%**
SFK-A	6.33	6.02	6.34	**-4.8%**	0.2%	6.40	6.40	6.42	0.0%	0.2%	6.65	6.68	6.65	0.4%	-0.1%
SFK-B	3.45	3.42	3.46	-1.0%	0.2%	3.25	3.23	3.26	-0.6%	0.1%	3.15	3.14	3.15	-0.2%	0.0%
SFK-C	2.31	2.77	2.69	20.2%	16.7%	2.66	3.21	3.00	20.8%	12.6%	4.43	4.89	4.27	10.3%	**-3.7%**
SFK-1.190	0.80	0.73	0.74	**-8.5%**	**-7.3%**	0.84	0.81	0.82	**-3.1%**	**-2.0%**	1.05	1.02	1.02	**-3.6%**	**-2.9%**
UTC-B	1.35	1.35	1.35	-0.1%	0.0%	1.03	1.03	1.03	-0.2%	-0.1%	0.72	0.72	0.72	-0.2%	-0.1%
UTC-C	3.25	3.25	3.25	-0.1%	0.0%	2.94	2.93	2.93	-0.1%	0.0%	2.63	2.63	2.63	-0.1%	0.0%
UTC-D	5.93	5.94	5.93	0.1%	0.0%	5.94	5.96	5.94	0.2%	0.0%	6.53	6.54	6.53	0.2%	0.1%
UTC-E	3.57	3.57	3.57	0.1%	-0.1%	3.39	3.40	3.39	0.3%	0.0%	3.64	3.65	3.64	0.3%	0.1%
UTC-F	2.25	2.25	2.25	-0.1%	0.2%	2.24	2.24	2.24	0.3%	0.1%	2.38	2.39	2.39	0.7%	0.5%
UTC-1.190	0.15	0.15	0.15	0.0%	-0.2%	0.16	0.16	0.15	0.0%	-0.3%	0.16	0.16	0.16	0.0%	0.0%
Rainbow Trout															
KR	14.24	14.52	14.39	2.0%	1.1%	15.28	15.25	15.30	-0.2%	0.1%	14.77	14.89	14.83	0.9%	0.4%
NFK-A	5.70	5.69	5.70	-0.2%	-0.1%	5.07	5.18	5.10	2.0%	0.5%	5.02	5.29	5.13	5.3%	2.1%
NFK-B	3.62	3.57	3.60	-1.3%	-0.4%	3.01	3.07	3.00	2.1%	-0.1%	3.26	3.36	3.29	3.0%	1.1%
NFK-C	5.90	5.85	5.86	-0.8%	-0.6%	5.05	5.34	5.07	5.7%	0.4%	4.98	5.57	5.24	11.8%	5.2%
NFK-D	0.77	0.94	0.85	22.8%	11.1%	0.64	0.89	0.74	39.8%	16.1%	0.65	0.88	0.74	35.9%	13.6%
NFK-1.190	0.05	0.01	0.01	**-88.3%**	**-88.3%**	0.04	0.00	0.00	**-89.7%**	**-89.7%**	0.05	0.01	0.01	**-87.3%**	**-87.3%**
SFK-A	8.48	8.47	8.59	-0.2%	1.2%	8.33	8.19	8.39	-1.7%	0.7%	9.24	9.21	9.35	-0.3%	1.2%
SFK-B	3.60	3.60	3.66	0.0%	1.7%	3.47	3.42	3.54	-1.5%	1.9%	4.01	3.99	4.11	-0.3%	2.7%
SFK-C	3.31	3.37	3.53	1.7%	6.7%	3.04	3.06	3.27	0.6%	7.5%	3.65	3.82	4.11	4.6%	12.5%
SFK-1.190	1.00	0.91	0.89	**-9.1%**	**-11.4%**	0.82	0.72	0.70	**-12.1%**	**-14.2%**	0.79	0.68	0.66	**-13.4%**	**-16.0%**
UTC-B	2.64	2.64	2.64	0.0%	0.0%	2.74	2.74	2.74	0.0%	0.0%	2.76	2.76	2.76	0.0%	0.0%
UTC-C	4.24	4.24	4.24	0.0%	0.0%	4.26	4.26	4.26	0.0%	0.0%	4.30	4.30	4.29	0.0%	0.0%
UTC-D	6.42	6.43	6.42	0.2%	0.1%	7.03	7.04	7.03	0.1%	0.1%	6.57	6.58	6.57	0.2%	0.1%
UTC-E	4.57	4.59	4.58	0.3%	0.1%	4.87	4.88	4.88	0.3%	0.1%	4.35	4.36	4.35	0.3%	0.1%

Table K4.24-2: Predicted Quantity (acres) of Suitable Juvenile Rearing Habitat by Species, Reach, Water Year, and Mine Operational Period

Basin-Reach	Juvenile Rearing—Wet Year					Juvenile Rearing—Average Year					Juvenile Rearing—Dry Year				
	Pre-Mine	Mine Operations	Mine Closure	Mine Operations	Mine Closure	Pre-Mine	Mine Operations	Mine Closure	Mine Operations	Mine Closure	Pre-Mine	Mine Operations	Mine Closure	Mine Operations	Mine Closure
	(acres)	(acres)	(acres)	(% diff)	(% diff)	(acres)	(acres)	(acres)	(% diff)	(% diff)	(acres)	(acres)	(acres)	(% diff)	(% diff)
UTC-F	2.09	2.12	2.10	1.5%	0.4%	2.15	2.18	2.21	1.5%	2.6%	2.09	2.11	2.10	1.1%	0.5%
UTC-1.190	0.06	0.06	0.06	0.0%	0.5%	0.06	0.06	0.06	0.0%	0.6%	0.06	0.06	0.06	0.0%	0.6%
Dolly Varden															
KR	14.57	14.70	14.69	0.8%	0.8%	13.80	13.68	13.78	-0.8%	-0.2%	14.00	13.99	14.02	-0.1%	0.2%
NFK-A	5.83	5.80	5.82	-0.6%	-0.2%	5.72	5.78	5.77	1.0%	0.8%	5.16	5.62	5.36	8.9%	3.9%
NFK-B	6.56	6.48	6.53	-1.2%	-0.4%	5.87	6.00	5.91	2.2%	0.7%	5.84	6.24	6.02	6.8%	2.9%
NFK-C	6.75	6.94	6.80	2.9%	0.7%	6.69	7.14	6.80	6.7%	1.7%	5.67	6.76	6.30	19.3%	11.1%
NFK-D	1.38	1.23	1.43	**-11.4%**	3.0%	1.28	1.41	1.52	9.8%	19.1%	1.13	1.33	1.34	17.4%	18.1%
NFK-1.190	0.07	0.02	0.02	**-62.8%**	**-62.8%**	0.07	0.02	0.02	**-73.3%**	**-73.3%**	0.07	0.02	0.02	**-63.7%**	**-63.7%**
SFK-A	8.54	8.56	8.65	0.2%	1.2%	9.13	8.96	9.10	-1.8%	-0.3%	9.29	9.31	9.26	0.2%	-0.3%
SFK-B	4.27	4.27	4.32	0.1%	1.2%	4.60	4.58	4.61	-0.4%	0.3%	4.70	4.71	4.70	0.3%	-0.1%
SFK-C	4.08	4.61	4.59	12.9%	12.4%	4.97	5.41	5.32	9.0%	7.2%	7.32	7.91	7.45	8.1%	1.8%
SFK-1.190	1.58	1.52	1.51	**-4.1%**	**-4.3%**	1.63	1.49	1.48	**-8.5%**	**-9.1%**	1.92	1.77	1.75	**-7.4%**	**-8.6%**
UTC-B	1.22	1.21	1.22	-0.1%	0.0%	0.98	0.98	0.98	-0.1%	-0.1%	0.97	0.97	0.97	-0.1%	0.0%
UTC-C	4.37	4.36	4.37	-0.2%	-0.1%	3.81	3.80	3.81	-0.2%	-0.1%	4.16	4.15	4.15	-0.2%	-0.2%
UTC-D	8.26	8.28	8.27	0.1%	0.1%	8.49	8.48	8.49	-0.1%	0.0%	8.47	8.48	8.48	0.1%	0.1%
UTC-E	5.61	5.63	5.62	0.4%	0.2%	6.22	6.23	6.22	0.2%	0.1%	5.80	5.82	5.81	0.4%	0.2%
UTC-F	3.74	3.76	3.75	0.5%	0.3%	3.75	3.76	3.72	0.3%	-0.8%	3.77	3.79	3.78	0.7%	0.3%
UTC-1.190	0.15	0.15	0.15	0.0%	0.1%	0.14	0.14	0.14	0.0%	0.0%	0.14	0.14	0.14	0.0%	0.1%
Arctic Grayling															
KR	21.91	22.11	22.08	0.9%	0.8%	21.15	21.01	21.13	-0.7%	-0.1%	21.26	21.25	21.29	-0.1%	0.1%
NFK-A	11.63	11.65	11.64	0.1%	0.0%	11.16	11.35	11.25	1.8%	0.8%	10.13	11.02	10.50	8.8%	3.6%
NFK-B	10.61	10.56	10.58	-0.4%	-0.2%	9.77	10.05	9.86	2.9%	0.9%	9.33	10.11	9.67	8.4%	3.6%
NFK-C	11.37	11.86	11.51	4.3%	1.2%	11.25	12.35	11.53	9.8%	2.5%	9.24	11.39	10.34	23.3%	11.9%
NFK-D	1.87	1.46	1.84	**-21.7%**	-1.2%	1.76	1.75	2.10	-0.4%	19.4%	1.51	1.69	1.81	11.5%	19.5%
NFK-1.190	0.12	0.04	0.04	**-70.8%**	**-70.8%**	0.12	0.03	0.03	**-78.0%**	**-78.0%**	0.11	0.03	0.03	**-68.9%**	**-68.9%**
SFK-A	14.95	14.99	15.14	0.3%	1.2%	16.12	15.84	16.08	-1.7%	-0.2%	16.74	16.77	16.69	0.2%	-0.3%
SFK-B	6.68	6.69	6.77	0.2%	1.3%	7.31	7.29	7.32	-0.3%	0.1%	7.55	7.58	7.53	0.4%	-0.3%
SFK-C	5.20	6.01	6.01	15.6%	15.5%	6.40	7.05	6.93	10.2%	8.4%	9.45	10.14	9.51	7.4%	0.7%
SFK-1.190	2.64	2.55	2.56	**-3.3%**	**-2.9%**	2.93	2.70	2.70	**-7.7%**	**-7.7%**	3.50	3.35	3.33	**-4.3%**	**-4.8%**
UTC-B	3.33	3.33	3.33	-0.1%	-0.1%	2.78	2.78	2.78	-0.1%	0.0%	2.81	2.81	2.81	-0.1%	0.0%
UTC-C	6.74	6.73	6.73	-0.1%	-0.1%	6.07	6.06	6.06	-0.1%	-0.1%	6.43	6.42	6.42	-0.1%	-0.1%
UTC-D	11.09	11.11	11.10	0.2%	0.1%	11.50	11.50	11.50	0.0%	0.0%	11.44	11.45	11.44	0.2%	0.1%

Table K4.24-2: Predicted Quantity (acres) of Suitable Juvenile Rearing Habitat by Species, Reach, Water Year, and Mine Operational Period

Basin-Reach	Juvenile Rearing—Wet Year					Juvenile Rearing—Average Year					Juvenile Rearing—Dry Year				
	Pre-Mine	Mine Operations	Mine Closure	Mine Operations	Mine Closure	Pre-Mine	Mine Operations	Mine Closure	Mine Operations	Mine Closure	Pre-Mine	Mine Operations	Mine Closure	Mine Operations	Mine Closure
	(acres)	(acres)	(acres)	(% diff)	(% diff)	(acres)	(acres)	(acres)	(% diff)	(% diff)	(acres)	(acres)	(acres)	(% diff)	(% diff)
UTC-E	7.94	7.97	7.95	0.4%	0.2%	8.52	8.52	8.52	0.0%	0.0%	8.08	8.12	8.10	0.5%	0.2%
UTC-F	5.51	5.54	5.53	0.5%	0.3%	5.54	5.56	5.50	0.3%	-0.8%	5.58	5.62	5.59	0.8%	0.3%
UTC-1.190	0.33	0.33	0.33	0.0%	-0.4%	0.33	0.33	0.32	0.0%	-0.6%	0.33	0.33	0.32	0.0%	-0.6%

Note: Percent decreases in habitat from pre-mine period exceeding 2 percent are shown in bold font.

Source: PLP 2019-RFI 149

Table K4.24-3: Predicted Quantity (acres) of Suitable Adult Rearing Habitat by Species, Reach, Water Year, and Mine Operational Period

Basin-Reach	Adult Rearing—Wet Year					Adult Rearing—Avg Year					Adult Rearing—Dry Year				
	Pre-Mine (acres)	Mine Operations (acres)	Mine Closure (acres)	Mine Operations (% diff)	Mine Closure (% diff)	Pre-Mine (acres)	Mine Operations (acres)	Mine Closure (acres)	Mine Operations (% diff)	Mine Closure (% diff)	Pre-Mine (acres)	Mine Operations (acres)	Mine Closure (acres)	Mine Operations (% diff)	Mine Closure (% diff)
Rainbow Trout															
KR	18.92	19.30	19.14	2.0%	1.2%	19.67	19.69	19.67	0.1%	0.0%	19.67	19.75	19.72	0.4%	0.3%
NFK-A	8.90	9.06	8.95	1.8%	0.6%	8.38	8.73	8.47	4.2%	1.1%	7.34	8.06	7.61	9.8%	3.6%
NFK-B	5.54	5.56	5.54	0.5%	0.1%	4.95	5.13	4.98	3.7%	0.6%	4.86	5.22	5.00	7.4%	2.9%
NFK-C	9.91	10.23	9.98	3.2%	0.7%	8.72	9.83	8.94	12.8%	2.5%	7.80	9.50	8.43	21.9%	8.2%
NFK-D	1.29	1.68	1.45	29.7%	11.6%	1.05	1.53	1.21	46.5%	15.4%	1.09	1.54	1.23	41.8%	13.4%
NFK-1.190	0.09	0.01	0.01	**-87.5%**	**-87.5%**	0.08	0.01	0.01	**-89.4%**	**-89.4%**	0.08	0.01	0.01	**-85.6%**	**-85.6%**
SFK-A	12.28	12.30	12.43	0.2%	1.3%	12.91	12.70	12.96	-1.6%	0.4%	14.45	14.46	14.53	0.1%	0.6%
SFK-B	4.94	4.99	5.02	1.0%	1.8%	5.46	5.43	5.57	-0.6%	1.9%	6.77	6.81	6.90	0.7%	1.9%
SFK-C	5.14	5.32	5.43	3.5%	5.8%	4.78	4.88	5.17	2.0%	8.2%	6.15	6.44	7.01	4.7%	14.1%
SFK-1.190	1.60	1.50	1.48	**-6.6%**	**-7.8%**	1.48	1.33	1.32	**-10.1%**	**-11.1%**	1.64	1.49	1.46	**-9.1%**	**-10.7%**
UTC-B	3.55	3.54	3.54	-0.3%	-0.3%	2.92	2.92	2.92	-0.3%	-0.2%	3.55	3.54	3.54	-0.3%	-0.3%
UTC-C	6.50	6.49	6.49	-0.1%	-0.1%	6.15	6.14	6.14	-0.2%	-0.1%	6.69	6.69	6.69	0.0%	-0.1%
UTC-D	8.52	8.54	8.53	0.2%	0.1%	9.08	9.08	9.08	0.0%	0.0%	8.98	9.00	8.99	0.2%	0.1%
UTC-E	6.88	6.91	6.90	0.4%	0.2%	7.50	7.51	7.51	0.2%	0.1%	6.90	6.93	6.92	0.3%	0.2%
UTC-F	4.01	4.08	4.03	1.7%	0.3%	4.24	4.31	4.39	1.7%	3.5%	4.12	4.18	4.15	1.3%	0.6%
UTC-1.190	0.17	0.17	0.17	0.0%	-0.6%	0.18	0.18	0.18	0.0%	-0.7%	0.18	0.18	0.18	0.0%	-0.7%
Dolly Varden															
KR	15.16	15.29	15.27	0.8%	0.7%	14.33	14.22	14.31	-0.8%	-0.1%	14.50	14.50	14.53	0.0%	0.2%
NFK-A	5.67	5.60	5.65	-1.3%	-0.4%	5.73	5.75	5.78	0.2%	0.8%	5.08	5.56	5.30	9.6%	4.4%
NFK-B	6.25	6.14	6.22	-1.8%	-0.5%	5.48	5.59	5.51	2.0%	0.6%	5.54	5.84	5.67	5.5%	2.4%
NFK-C	7.07	7.23	7.12	2.3%	0.7%	7.24	7.59	7.36	4.8%	1.6%	6.08	7.19	6.79	18.2%	11.7%
NFK-D	1.60	1.44	1.68	**-10.3%**	4.5%	1.49	1.66	1.77	11.6%	19.1%	1.31	1.54	1.55	17.2%	17.7%
NFK-1.190	0.07	0.02	0.02	**-67.5%**	**-67.5%**	0.08	0.02	0.02	**-76.3%**	**-76.3%**	0.07	0.02	0.02	**-66.1%**	**-66.1%**
SFK-A	8.47	8.48	8.57	0.1%	1.2%	8.97	8.81	8.95	-1.8%	-0.3%	9.11	9.12	9.09	0.1%	-0.2%
SFK-B	4.43	4.44	4.49	0.0%	1.3%	4.85	4.83	4.85	-0.3%	0.1%	4.90	4.91	4.88	0.4%	-0.4%
SFK-C	4.43	4.92	4.91	11.0%	10.9%	5.20	5.62	5.55	8.0%	6.7%	7.55	8.16	7.76	8.1%	2.9%
SFK-1.190	1.62	1.53	1.52	**-5.5%**	**-6.2%**	1.63	1.48	1.47	**-9.1%**	**-9.8%**	1.84	1.72	1.70	**-6.9%**	**-8.0%**
UTC-B	1.07	1.07	1.07	-0.1%	0.0%	0.89	0.88	0.89	-0.1%	0.0%	0.86	0.86	0.86	-0.1%	0.0%
UTC-C	4.50	4.49	4.49	-0.2%	-0.2%	3.85	3.85	3.85	-0.2%	-0.1%	4.28	4.27	4.27	-0.2%	-0.2%
UTC-D	9.12	9.14	9.13	0.1%	0.1%	9.42	9.42	9.42	0.0%	0.0%	9.33	9.35	9.34	0.1%	0.1%
UTC-E	6.25	6.27	6.26	0.4%	0.2%	6.90	6.91	6.90	0.2%	0.1%	6.43	6.45	6.44	0.4%	0.2%

Table K4.24-3: Predicted Quantity (acres) of Suitable Adult Rearing Habitat by Species, Reach, Water Year, and Mine Operational Period

Basin-Reach	Adult Rearing—Wet Year					Adult Rearing—Avg Year					Adult Rearing—Dry Year				
	Pre-Mine (acres)	Mine Operations (acres)	Mine Closure (acres)	Mine Operations (% diff)	Mine Closure (% diff)	Pre-Mine (acres)	Mine Operations (acres)	Mine Closure (acres)	Mine Operations (% diff)	Mine Closure (% diff)	Pre-Mine (acres)	Mine Operations (acres)	Mine Closure (acres)	Mine Operations (% diff)	Mine Closure (% diff)
UTC-F	4.18	4.22	4.20	1.0%	0.5%	4.20	4.24	4.19	0.8%	-0.3%	4.21	4.26	4.24	1.2%	0.5%
UTC-1.190	0.11	0.11	0.11	0.0%	0.2%	0.11	0.11	0.11	0.0%	0.1%	0.11	0.11	0.11	0.0%	0.1%
Arctic Grayling															
KR	10.18	10.41	10.30	2.3%	1.2%	11.28	11.27	11.29	-0.1%	0.1%	10.72	10.81	10.76	0.8%	0.4%
NFK-A	3.62	3.64	3.62	0.6%	0.1%	3.04	3.14	3.05	3.2%	0.3%	3.14	3.25	3.17	3.5%	1.1%
NFK-B	2.06	2.05	2.06	-0.5%	-0.3%	1.68	1.70	1.67	1.2%	-0.7%	1.94	1.99	1.95	2.2%	0.6%
NFK-C	4.12	4.08	4.07	-0.9%	-1.1%	3.15	3.42	3.14	8.6%	-0.3%	3.38	3.71	3.45	9.9%	2.0%
NFK-D	0.30	0.45	0.33	52.7%	10.7%	0.20	0.35	0.22	78.3%	9.1%	0.25	0.40	0.27	63.3%	10.0%
NFK-1.190	0.03	0.00	0.00	**-98.9%**	**-98.9%**	0.02	0.00	0.00	**-99.0%**	**-99.0%**	0.03	0.00	0.00	**-98.5%**	**-98.5%**
SFK-A	5.55	5.53	5.61	-0.4%	1.2%	5.21	5.12	5.26	-1.7%	1.1%	5.97	5.94	6.08	-0.5%	1.8%
SFK-B	2.29	2.28	2.33	-0.2%	1.8%	1.97	1.92	2.03	**-2.6%**	2.9%	2.40	2.37	2.51	-1.1%	4.6%
SFK-C	2.37	2.32	2.51	-1.8%	6.0%	1.87	1.80	2.05	**-4.0%**	9.6%	1.91	1.91	2.34	-0.1%	22.2%
SFK-1.190	0.53	0.47	0.46	**-10.8%**	**-13.8%**	0.40	0.34	0.33	**-13.4%**	**-16.3%**	0.32	0.27	0.25	**-17.9%**	**-21.4%**
UTC-B	1.98	1.98	1.98	0.0%	0.0%	1.91	1.91	1.91	-0.2%	-0.2%	2.04	2.04	2.04	0.0%	0.0%
UTC-C	3.20	3.21	3.21	0.1%	0.0%	3.44	3.44	3.44	0.1%	0.0%	3.36	3.37	3.37	0.1%	0.0%
UTC-D	3.34	3.36	3.35	0.4%	0.2%	3.88	3.89	3.88	0.2%	0.1%	3.53	3.54	3.54	0.3%	0.1%
UTC-E	2.86	2.87	2.87	0.3%	0.1%	2.96	2.97	2.96	0.3%	0.1%	2.58	2.58	2.58	0.2%	0.1%
UTC-F	1.13	1.14	1.13	0.7%	-0.1%	1.17	1.19	1.22	1.2%	3.6%	1.11	1.11	1.11	0.0%	-0.1%
UTC-1.190	0.02	0.02	0.02	0.0%	0.5%	0.02	0.02	0.02	0.0%	0.7%	0.02	0.02	0.02	0.0%	0.7%

Note: Percent decreases in habitat from pre-mine period exceeding 2 percent are shown in bold font.

Source: PLP 2019-RFI 149

Figure K4.24-3 to Figure K4.24-17: Map Series—Predicted Changes in the Amount (Acres) of Suitable Habitat from Pre-Mine to Mine Operations (Left) or to Mine Closure (Right) During an Average Water Year for Select Resident and Anadromous Fish[1]

[1] Line Colors Represent: Green=Increase >10%; Blue=Increase 2-10%; Yellow=No Change (+/- 2%); Pink=Decrease 2-10%; Red=Decrease >10%.